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WEST VIRGINIA UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
MORGANTOWN, W. VA.

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Mixtures and Appliances for Spraying.

By T. C. JOHNSON.

(The Bulletins and Reports of this Station will be mailed free to any citizen of West Viaginia upon written application. Address Director of Agricultural Experiment Station, Morgantown, W. Va.)

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PLATE I—A SPRAYED ORCHARD.

Mixtures and Appliances for Spraying.

INTRODUCTION.

There are two general types of difficulties confronting the fruit growers of the State which may be largely overcome by the proper employment of preventative measures. These naturally fall under the heads, fungus diseases and insect injurious. The greater number of treatments so far successfully used in the suppression of the former consists of copper in some of its compounds. Copper sulphate is generally considered the cheapest and most reliable base for the manufacture of these remedies. Though a simple solution of copper sulphate has been used for many years as a preventative for grain smut, it was not until 1882 that its great fungicidal power was realized. In that year Millardet, at Bordeaux, France, found that a compound of copper sulphate and lime, with which he treated his grapes to prevent their being eaten, greatly checked the mildew. From this accidental discovery made twenty-two years ago has been evolved the modern practice of spraying.

The injurious insects may, for convenience, be divided into two groups. 1st. Those which eat or chew the parts of the plant, and are, therefore, killed by the application of some poison. Such insects as the cucumber and potato beetles, the codling moth and the currant worm belong to this class. 2nd. Insects which suck their food from the plant by inserting the proboscis through the epidermis. These are destroyed by contact applications of a caustic nature. All the plant lice and scale insects, which have become such a great menace recently, belong here. For these the kerosene emulsion, lime-sulphur washes and the like are specifics.

Spraying has become such an important orchard practice lately that many people look upon it as a panacea for all sorts of orchard troubles. If it is to have the effect of depreciating cultivation and fertilization then it had better never have come into use. A tree

must grow before it can bear fruit and the growth depends upon the care given it. A successful orchard must have good tillage, an abundant supply of plant food to meet all requirements, proper pruning, and spraying. Spraying is one of the essentials but it should not obscure the other three.

Spraying should be looked upon as a means of insurance. It may be that the fruit plantation will not be seriously affected by insects or fungi every season, yet experience has taught that visitations from these pests may be expected at least four years out of five. It is the part of wisdom to anticipate the trouble and to insure against it by spraying. As it is too late to take out an insurance policy after the house is on fire so it is too late to spray after the scab has made its appearance on the fruit. Because unsprayed orchards in a few sections of the State were comparatively free from injury by insects or fungi is no argument against spraying. The weather conditions are undoubtedly large factors in determining the development of fungi, but though the conditions were unfavorable for this development in some portions of the State which suffered so much from drouth last season yet it would not be safe to infer that the conditions will not be reversed next season. It is a common fault to draw conclusions from the experience of each recurring season and not from the result of the aggregate experiences of a number of years. Every step in orchard management should rest upon some fundamental principle.

Spraying is of some value every season. Even in years of comparative immunity sprayed trees carry much better foliage than those untreated, and, as good foliage is absolutely essential to the proper growth of both wood and fruit, it is advisable to spray. Nor are all the good results of spraying manifest the current year. The better foliage enables the tree to develop more vigorous fruit buds for the succeeding season's bloom. When there is a light crop it is even more imperative that spraying should be throughly and faithfully done than when the trees are heavily loaded. The sparce crop affording only a limited amount of material for the insects and fungi to breed upon renders the liability to injury much greater.

Spraying should be thoroughly done. No slipshod work will answer here. Probably one-third of the spraying ordinarily done is a waste of time and material. A tree is thoroughly sprayed when it

is wet over the entire surface, on the under as well as the top side of the leaves and branches. The plant should not be drenched but simply thoroughly moistened. If the spray reaches the foliage in coarse drops or if too much is applied it drips to the ground, but if the proper amount is applied in the form of a very fine mist it will adhere to the foliage much better. Enough should be put on to moisten the foliage thoroughly but not enough to drip. It is sometimes advisable to make two light applications at an interval of a few hours, thus permitting the first to dry before the second is put on. The spray kills only the fungus spores with which it comes into contact and since they are all so very small it is an easy matter for them to find lodgment on minute spots of the foliage which no copper solution has reached if the spraying was carelessly done.

It is well to have a clear idea of what the particular spray mixture is for before applying it. Much valuable time is wasted in using the wrong mixture. Bordeaux mixture will not kill codling moths, nor will paris green rid the orchard of apple scab. It is not absolutely essential that the orchardist know the entire life history of every insect or fungus that infests his trees, but he should, at lest, have some knowledge of their vulnerable points and the treatments usually applied.

The arsenical poisons are used to kill those insects which chew the leaves, shoots or fruit—such as the bud moth, potato beetle, canker worm, codling moth and tent caterpillar. The contact insecticides such as kerosene emulsion and whale oil soap are used to kill plant lice and soft scale insects, while lime-sulphur wash is used to kill San Jose scale. Bordeaux mixture and ammoniacal carbonate of copper are used to prevent the attacks of parasitic fungi such as apple-scab, grape mildew and potato blight.

The orchadist must determine when and how often to spray, and this can only be done by knowing something of the enemies he wishes to reach. If the fruit plantation is infested with San Jose scale the spraying should be done during the winter season while the trees are dormant. But if the bud moth is causing the trouble an application containing an arsenical poison should be made as the buds begin to swell. However, for the worst enemies of the fruit growers in this State—the apple scab and codling moth, two or

preferably three sprayings should be given. The spray should consist of bordeaux mixture with paris green or white arsenic added at the rate of four or five ounces to fifty gallons of the liquid. The exact time of the applications for the best results is not yet definitely settled, but in general, the first application should be made just before the buds open and the second as the last blossoms fall. A third and fourth application may, with profit, follow at intervals of two weeks. However, the poison may be omitted from the last.

PREPARATION OF FUNGICIDES AND INSECTICIDES.

Spray mixtures may be divided into two general classes; *fungicides,* or those used in combatting fungous diseases, and *insecticides,* or those used against insects. This class of insecticides are readily separated into two subdivisions, those causing death by being taken internally with the food and those that kill by coming into contact with the body. Still a third class, gases, which causes the death of the insect by entering the body through the respiratory organs is extensively used in treating nursery and greenhouse stock. The arsenical poisons are frequently mixed with bordeaux thus forming a combination spray possessing both insecticidal and fungicidal properties.

The insecticides and fungicides treated in this bulletn are named in the folowing list:

FUNGICIDES.

Bordeaux mixture.
Soda bordeaux mixture.
Copper sulphate solution.
Ammoniacal carbonate of copper.
Potassium Sulphide.
Iron Sulphide and sulphuric acid solution.
Corrosive sublimate.
Formalin solution.
Maxwell dust spray.
Missouri Experiment Station dust spray.

BORDEAUX MIXTURE.

Bordeaux mixture continues to hold the most important place in

garden and farm crops, such as apple-scab, black-rot, bitter-rot, potato-mildew, etc. There is such a constant demand for information regarding the proper preparation and application of this mixture that the subject is treated somewhat fully in this bulletin.

The essential ingredients are copper-sulphate, lime and water. The fungicidal properties rest in the copper sulphate. The lime neutralizes the acid of the copper sulphate, and makes the mixture more adhensive and more easily seen after being applied. The water acts simply as a carrier for the other materials.

There is a very little danger from using impure materials. Copper sulphate is such a staple article that no complaints have been sustained against it on the grounds of impurity. Lime is more variable on account of the different grades of rock from which it is manufactured. The relative amounts of lime and copper sulphate may be greatly varied because an excess of lime will do no injury to the foliage. It is absolutely essential that sufficient lime be used to neutralize the acid in the copper sulphate or injury to the foilage will surely follow. The quantity of lime should never be gauged by weight alone, because of the great variability in its purity. Some convenient test, such as the ferrocyanide of potassium (yellow prussiate of potash) test, may be employed to determine the proper lime content. Ordinarily two pounds of quick lime is sufficient to satisfy the ferrocyanide test for three pounds of copper sulphate, but in view of recent experiments at this station, a larger proportion of lime is desirable. If the weather should be cold and damp immediately after applying the spray, severe injury to the foliage is apt to follow the use of an insufficient quantity of lime, while too much lime renders the mixture so thick that it will not pass readily through the spray nozzle. Under ordinary circumstances the lime should not greatly exceed the copper sulphate in weight, since a great excess of lime seems to render the bordeaux less efficient as a fungicide, but the best results are usually obtained when the weight of the lime equals that of the copper sulphate.

Since good lime poorly slaked will give unsatisfactory results the method of slaking it is of as great importance as the quantity used. The lime should be fresh, firm, and free from impurities. In slaking the best results are obtained by adding first a little water, preferably warm, and more as needed after slaking begins. Enough

water should be added to prevent air slaking, but not enough to completely submerge it. When too much water is added particles of the lime may remain unslaked. As soon as slaking is complete, the mixture may be diluted to the required consistency by adding water slowly while stirring.

The strength of the bordeaux to be used depends upon the character of the plants and the nature of the fungi to be combated. For use in the apple orchard where the application is thoroughly made, a strength of one pound of copper sulphate to eleven or twelve gallons of water will usually give satisfactory results; while for potatoes the solution should be much stronger, 1 to 7 or 1 to 8. The foliage of the peach and Japanese plum is best treated with a strength of not over 1 to 25 or 1 to 20. For treatment of fruit trees in dormant condition the proportion of copper sulphate may be as high as one pound to six or eight gallons of water.

The proper mixing of the solution of lime and copper sulphate is of utmost importance. In order to get a clear understanding of the subject the simple method of weighing and measuring will first be considered.

BORDEAUX MIXTURE.

(To make 50 gallons.)

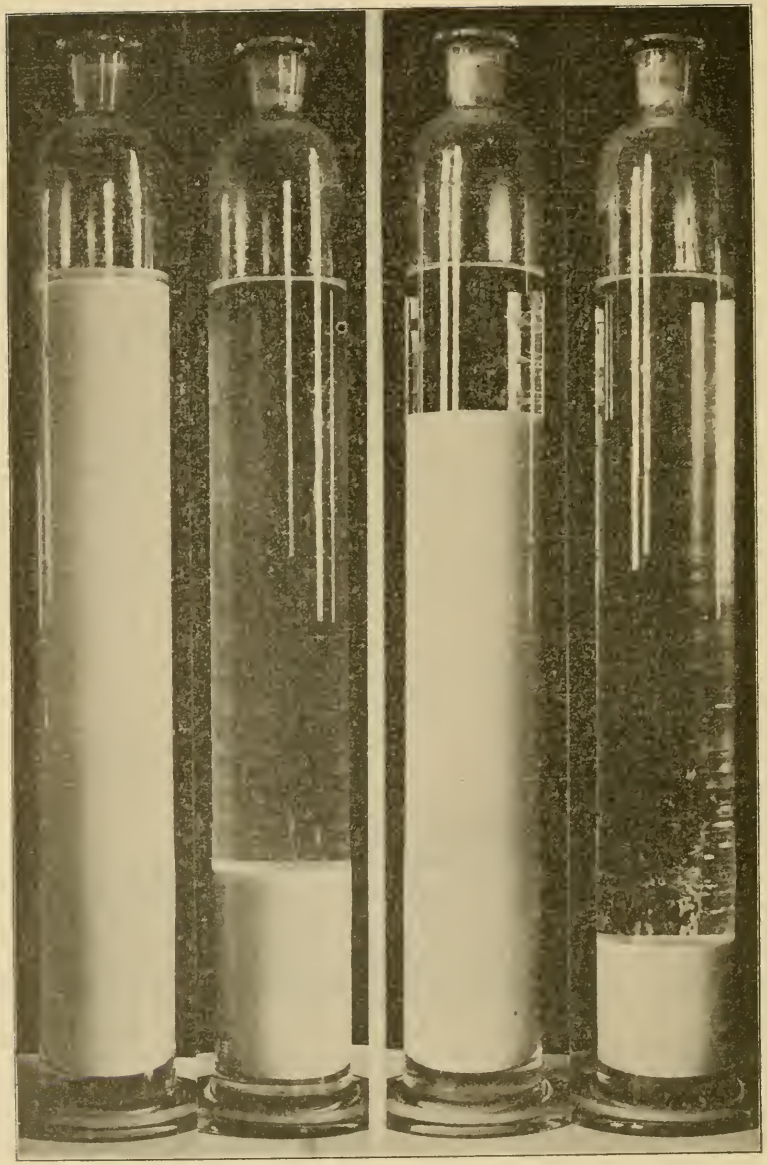
Copper Sulphate, (blue vitrol)	4 pounds.
Lime (unslaked) .....4 to	6 pounds.
Water	50 gallons.

1.—Dissolve the four pounds of copper sulphate in three or four gallons of either hot or cold water, using a vessel which the copper will not corrode, such as wood, porcelain or stone-ware. Dilute the solution with water to twenty-four gallons.

2. Slake the lime by adding small quantities of either hot or cold water gradually. After slaking is complete dilute the lime solution to twenty-four gallons. It should then be strained through a gunny sack or seive to remove the particles which might clog the spray nozzle.

3.—Pour the two dilute solution simultaneously into a third vessel, stirring constantly.

This gives forty-eight gallons which will admit of the addition of two gallons more of the lime solution should the test indicate a



A B A B

Fig. 1. Fig. 2.

deficiency, otherwise water may be added to bring the mixture up to the required fifty gallons. *Never mix the concentrated solutions together,* and always have them cool before mixing. If mixed in the concentrated form the resultant particles will not remain in suspension. When the mixture holds up well it is a better carrier for poisons, such as paris green, which do not go into solution but simply remain in suspension. This also admits of a much more uniform application to the foliage, which is all important. How much better the particles remain in suspension when the ingredients are properly mixed than when it is improperly done may be seen by consulting plate II figures 1 and 2. Figure 1 shows the mixture after standing forty-five minutes, and figure 2 after four hours and thirty minutes. A. was made by mixing the dilute, and B. the concentrated solutions.

Where a large amount of spraying is to be done, it is often convenient to prepare bordeaux from stock solutions of both copper sulphate and lime. A saturated solution of the copper sulphate, which contains about three pounds of the sulphate to a gallon of water at a temperature of 60° F., may be prepared by placing twenty-five gallons of water in a barrel and suspending slightly more than seventy-five pounds of the copper sulphate crystals in a gunny sack or basket just beneath the surface of the liquid. After a day or two the water will have dissolved all the copper sulphate it can hold thus rendering it a saturated solution. Each gallon of the solution will contain very slightly in excess of three pounds of the copper sulphate as long as the temperature remains at 60°. Thus in preparing bordeaux, one and two-thirds gallons of the solution would contain the five pounds of copper required. Some orchardists prefer to have the stock solution contain two pounds of copper sulphate to the gallon, but the difficulty with this strength is, that some of the water is very apt to be lost by evaporation, thus rendering the remaining portion more concentrated.

Stock solutions of lime may be prepared by slaking a considerable quantity in a barrel or preferably a water-tight box and diluting with sufficient water so the solution will contain about two pounds of lime to the gallon. The lime paste will gradually settle to the bottom leaving the clear liquid on the surface. This paste may be kept throughout the season. The only precaution necessary being

to keep the surface constantly covered with an inch or more of water. Never allow the lime paste to become dry. If any of the water should be lost by evaporation, the paste should be diluted to approximately the strength above indicated before using.

Several methods are known whereby the bordeaux mixture may be tested to show whether it contains sufficient lime to combine with all the copper. Prominent among these is the ferrocyanide of potassium test, previously mentioned, commonly called the "ferrocyanide" test. Ferrocynide of potassium is a yellow salt which dissolves readily in water. One ounce of it dissolved in five or six ounces of water will ordinarily last through the season. In preparing the bordeaux mixture with this test, take from the stock solution of copper, a sufficient quantity of the liquid to contain the required amount of sulphate and dilute to a quantity a little less than one-half the amount of bordeaux needed. Next take from the stock solution of lime enough to contain approxmately the amount of dry lime called for by the formula, and dilute with water to about one-half the required amount of spray as was done with the copper sulphate. The solutions may now be poured together simultaneously into a third vessel and thoroughly stirred. Place a small quantity of the mixture thus prepared in a saucer and add a few drops of the ferrocyanide solution. If a reddish-brown color appears it is an indication that the mixture is deficient in lime and more should be added until no dis-coloration appears. Even after the test shows no color a little more lime should be added to make sure that all the copper has been precipatated, for in case the mixture has not been thoroughly stirred, some of the unprecipitated copper, which the test failed to show, may still remain in solution in the bottom of the barrel.

Since, ordinarily, two pounds of lime will satisfy the color test for three pounds of copper sulphate it is an easy matter to determine, by the aid of the ferrocynide test, the amount of lime paste required to fulfill the conditions of any formula. If for example, the formula calls for four pounds of copper sulphate, four pounds of lime and fifty gallons of water, when the test first shows that enough lime is present to combine with all the copper sulphate the mixture will contain two and two-thirds pounds of lime. To com-

plete the mixture simply add a quantity of the lime paste equal to one-half of that already used.

Where a large amount of spraying is to be done, a convenient mixing device will greatly facilitate the work. Such a device should consist of two diluting tanks of 150 gallons capacity, a mixing tank of 300 gallon capacity, a box in which to slake lime, a barrel for storing the slaked material, two or three barrels in which to prepare and store the concentrated copper sulphate solution, and a force pump and hose.

The mixing tank should be so elevated as to permit an easy flow of the liquid from a hose attachment near the bottom to the spray tank on the wagon, and the bottoms of the diluting tanks should be fitted with large faucets and pipe connections set into the bottoms to allow their contents to drain into the mixing tank. The faucets should both empty into a strainer of fine brass wire, (twenty meshes to the inch), placed near the top of the mixing tank. To prepare, say 200 gallons of 4-4-50 bordeaux, place enough of the concentrated copper sulphate solution to contain sixteen pounds, of sulphate in one diluting tank and lime paste containing an equal amount of lime in the other; pump enough water into each tank to bring the contents up to 100 gallons. Now open both faucets and let the liquids flow together into the strainer. This thoroughly mixes them and also removes coarse particles which may be present. The bordeaux should be given the ferrocyanide test and if found correct it is ready to be drawn off into the spray tank.

If a gravity system of water is available all heavy lifting and pumping can easily be avoided.

Two men should be able to do all the mixing and apply the ferrocyanide test for at least twenty 200-gallon tanks per day.

SODA BORDEAUX.

Recent experiments with soda bordeaux at this station have proved so very satisfactory that somewhat full directions are here given for its preparation. Soda bordeaux is made by adding caustic soda (commercial lye) to a solution of copper sulphate until the mixture reaches exact neutrality. In the hands of inexperienced users this mixture often results disastrously to the foliage because of an ex-

cess of one or the other of the ingredients. This danger may be largely eliminated if lime is added to the neutral mixture, in the form of a thin milk of lime at the rate of one ounce of lime to six ounces of copper sulphate. Some fruit growers experience considerable trouble in bringing the solution to exact neutrality. To assist in removing this difficulty the following table is quoted from a recent New Jersey bulletin on the subject. The table shows the power of a can of each of the brands of "potash or lye" mentioned to neutralize copper sulphate, and the amount of bordeaux mixture it will produce. Soda is given first in the list for comparison.

Table Showing the Strength of Various Commercial Lyes.

	Gross weight of can.	Weight of substance.	Copper sulphate required.	Amount Mixture.
Soda (Troy)	11.2 lbs.	10.17 lbs.	46.22 lbs.	462 gal.
Babbitt Potash	17 oz.	14.75 oz	3 "	30 "
Champion	13.75 oz.	12 "	1.6 "	16 "
Red Seal	17 "	14.5 "	2.4 "	24 "
Leggett	17 "	14.75 "	2.5 "	25 "
Lehman's	14.75 "	12.25 "	2.4 "	24 "
Hirsh	14.5 "	12.75 "	1.8 "	18 "
Washington	14.25 "	12.75 "	1.7 "	17 "
Saponifier (solid)	15.75 "	14.25 "	1.5 "	25 "
Saponifier (granulated)	17 "	74.75 "	2.6 "	26 "
Natroma	43.75 "	36.75 "	7.2 "	72 "

PREPARATION OF SODA BORDEAUX.

In the preparation of the material for spraying, copper sulphate is usually employed at the rate of one pound to ten gallons of water. Directions for putting copper sulphate into solution will be found under bordeaux mixture. "For example, if about fifty gallons of soda-bordeaux are desired, ascertain from the table the number of cans of soda required. This number will vary with the brand. The amount of copper sulphate will depend upon the brand selected. The contents of two or more of the one-pound cans will readily dissolve in a gallon of water, and, before using, this solution should be diluted. For quantities of soda-bordeaux ranging from twenty-five to sixty gallons, dilute the soda solution to about fifteen gallons and pour it slowly into ten gallon solution of copper, Stir the mixture thoroughly, and, after about two-thirds of the soda has been added, test frequently with red litmus. As soon as there is a change in color, from red to blue, cease adding the soda

PLATE III.

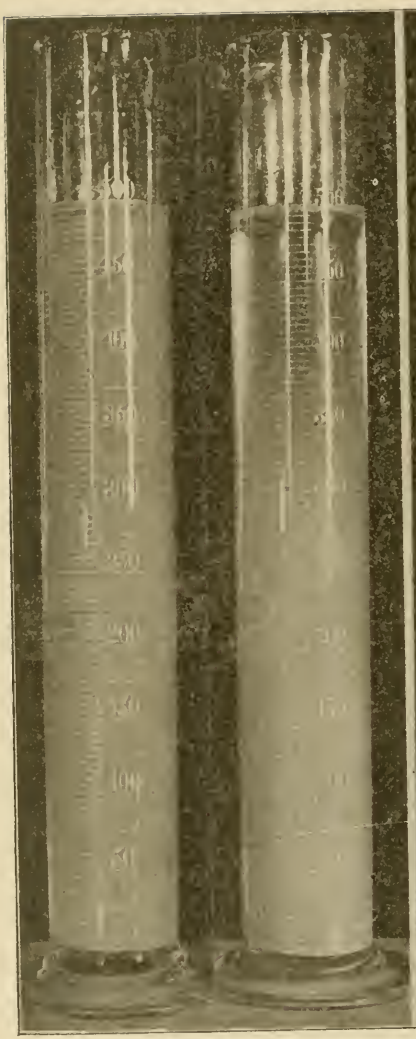


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Fig. 3.

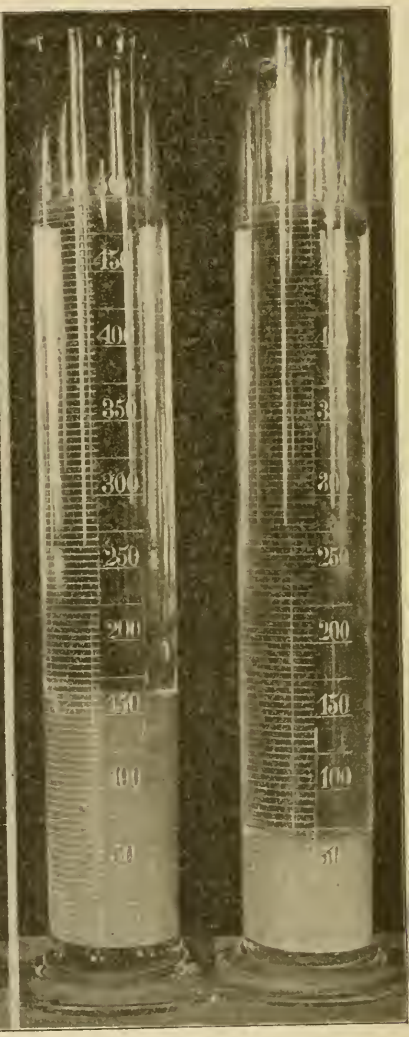

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Fig. 4,

solution. Add slaked lime in the form of a thin whitewash, previously strained, at the rate of five ounces to thirty gallons. Dilute the mixture to ten gallons of water to one pound of copper sulphate, and it is ready for use."

Since the strength of the different brands of commercial lye, and, in fact, often the same brand purchased at different times is not constant, it is well not to put too much dependence on the values given in the table but to make one's own determination. This can be conveniently done as follows:

Dissolve two pounds of copper sulphate in sixteen pints of water in a glass, earthen or wooden vessel. After all crystals of the copper sulphate have dissolved, place one-half of the solution in a second vessel. Then dissolve one pound of commercial lye in four pints of water in a third glass or earthen vessel, and, after cooling, make up to eight pints of the solution. Stir both the copper solution in vessel No. 2, and the soda solution in vessel No. 3, before proceeding, using a wooden paddle. Now pour two pints of the lye solution into the copper sulphate solution in vessel No. 2, and allow the mixture to settle. Test the liquid in vessel No. 2, with blue litmus paper by dipping it into the clear liquid. If the litmus paper should turn red it is an indication that not enough lye has been added. Now add accurately measured quantities of the lye solution slowly until the copper sulphate solution ceases to turn the blue litmus paper red. This should require from two to six pints, depending on the strength of the lye used. The solution is neutral when sufficient lye has been added so that it will not change the color of either red or blue litmus paper. If for any reason too much lye has been added and the soda bordeaux rendered strongly alkaline, it may be neutralized by the addition of some of the copper sulphate solution from vessel No. 1. The quantity added should be carefully measured.

If five parts of the lye solution is required to neutralize eight parts of copper sulphate, the substances should be used in the soda bordeaux in the proportion of eight parts of copper to five of lye. The addition of a small amount of lime, at the rate above indicated, should never be omitted. Never mix copper sulphate, lye or lime solutions together in a concentrated form.

All measurements should be carefully and accurately made, as an error here would be multiplied in the final mixture.

COPPER SULPHATE SOLUTION.

Copper Sulphate	1 pound.
Water	20-25 gallons.

For late winter and early spring use on the apple and grape, this is fully as effective as bordeaux mixture and is much easier prepared and applied. It is said to effectively destroy the spores of the fugus, *Exoascus deformans,* Fuckl., which causes the peach leaf curl, if applied early in April. In no case should an application of the above strength be made after the buds begin to open.

A weak solution containing one pound of copper sulphate to 200 or 300 gallons of water is sometimes recommended as a substitute for ammonical carbonate of copper for use in spraying ripening fruit, especially plums and peaches. But since their foliage is quite susceptible to injury from copper compounds, a mixture containing this element in any of its forms, should be very dilute. The extreme dilution, of course, lessens its fungicidal efficiency.

AMMONIACAL CARBONATE OF COPPER.

Copper Carbonate	5 ounces.
Ammonia (26° Beaume	3 pints.
Water	40 gallons.

Dissolve the copper carbonate in the ammonia, agitating if necessary. If left exposed the solution loses strength, but it may be preserved throughout the season if put into a tightly corked bottle. To prepare for use dilute as much of the liquid as contains one ounce of the copper carbonate with nine gallons of water. For spraying peach or Japanese plum foliage, the strength of the solution should not exceed one ounce of copper carbonate to twelve gallons of water.

It is often difficult to find copper carbonate on the market, but it may be easily made at home as follows: Dissolve ten pounds of copper sulphate in ten gallons of water, also twelve pounds carbonate of soda in the same quantity of water. When cool, mix the two solutions slowly, stirring well. Allow the mixture to stand twelve hours and settle, after which pour off the liquid. Add the

same quantity of water as before, stir and allow to stand the same length of time. Repeat the operation, after which drain and dry the blue powder, which is copper carbonate.

POTASSIUM SULPHIDE SOLUTION.

This solution is employed for mildew in greenhouses, mildew on roses and goose-berries, and other powdery mildews. Its action seems more rapid than that of bordeaux mixture, but not so lasting. It is perfectly harmless and does not discolor the fruit. The solution loses strength by standing, hence should be used immediately.

IRON SULPHATE AND SULPHURIC ACID SOLUTION.

Iron Sulphate, (Copperas)	50 pounds.
Sulphuric Acid	1 pint.
Water	12½ gallons.

Place the copperas in a wooden or earthenware vessel, pour on the acid and add hot water. Use as soon as cool. Great care should be exercised in the preparation as it is extremely caustic, and will injure the hands, clothing, and machinery. It is applied as a wash with a mop made by tying rags about the end of a stick. It is a valuable treatment for anthracnose of the grape. Dormant vines are uninjured by the treatment.

CORROSIVE SUBLIMATE.

Corrosive Sublimate	2 ounces
Water	15½ gallons.

This is a very common and effective remedy for potato scab. Soak the tubers in the solution for one and one-half hours, then dry and plant in scab-free soil. Corrosive sublimate is also used for disinfection purposes. It should be used with caution, as it is very poisonous. In preparing and applying the mixture, always use an earthen or wooden vessel.

FORMALIN SOLUTION.

For Potato Scab.

Formalin (40 per cent. Formaldehyde)	1 pint.
Water	30 gallons.

Soak the tubers in the liquid for about two hours, dry and plant.

For Grain Smut.

Formalin	1 pint.
Water	45 gallons.

The solution may be applied to the grain in any manner which allows the entire surface to become moist.

Sprinkling and shoveling, if well done, is as effective as dipping and more rapid. Place the grain on a tight floor or canvas and apply the liquid by means of a sprinkling pot or small hand spray pump, and shovel or rake over until the grains seems to be evenly moist. It should remain in the pile a few hours before sowing.

It will require about three quarts of the liquid for a bushel of wheat and six quarts for a bushel of oats or barley.

If the grain is to be used for seed it should be measured before treatment and again after to ascertain how the drill should be set to get the required amount of the swelled seed per acre.

DUST SPRAYS.

The application of a modified bordeaux mixture in a dry form is now extensively practiced in some portions of the country, especially in very steep orchards or where the water supply is limited. Tests have shown that the dust form is not as effective as the liquid, but the results are sufficiently good to justify a trial. The dust is now prepared according to one of three general methods.

MAXWELL DUST SPRAY.

Lime (unslaked)	1 barrel.
Copper Sulphate	25 pounds.
Concentrated Lye	5 pounds.
Sulphur (powdered)	25 pounds.
Paris Green	6 pounds.

Dissolve the copper sulphate in six gallons of boiling water and the lye in five gallons of hot water. Keep separate. Break the lime into small pieces and spread in a large flat bottomed box. Slake the lime by slowly sprinkling an the hot copper sulphate solution. Follow with the lye. If the lime is not thoroughly slaked add clear water slowly. Screen the lime through a fine sieve, rub the sulphur through the sieve into the lime, and add the

paris green. Thoroughly mix the ingredients. This should give a powdery dust.

MISSOURI EXPERIMENT STATION DUST SPRAY.

Copper Sulphate	4 pounds.
Lime (unslaked)	4 pounds.
Lime (air slaked)	60 pounds.
Water	5 gallons.

Dissolve the copper sulphate in two and one-half gallons of hot water and slake the quick lime in a like amount of water. Pour simultaneously into a third vessel the copper sulphate solution, and the milk of lime, thoroughly stir. Strain the surplus water off and mix thoroughly the remaining wet material with the sixty pounds of air-slaked lime. The mixture should then be perfectly dried and all lumps sifted out. A pound of paris green may be added for insecticidal purposes.

Prof. Newell objects to this dust on three grounds: 1.—"The possibility of having present other copper compounds than the hydroxide when such concentrated solutions of copper sulphate and lime are brought together." 2.—"The amount of time and labor required in preparing the dust, and 3.—"The physical condition of the completed product." To over-come these difficulties it is suggested that the solution be brought together in a dilute form as is done in making bordeaux mixture, and that the *air slaked lime be omitted.*

The bordeaux is made in the ordinary way and let stand until the precipitate has settled to the bottom, which requires from eighteen to twenty-four hours. The clear liquid is then dipped off and the precipitate poured into a bag made of closely woven cotton cloth. It is then suspended from a pole and allowed to drain for three or four hours. Next, put it into a shallow box with tight bottom to dry. When dry the substance is a light blue, friable mass, which readily crumbles to a powder.

INSECTICIDES.

Ingested Poisons.

Paris green.
White arsenic.

1. Arsenite of soda.
2. Arsenite of lime.

Lead arsenete.
Hellebore.

Contact Remedies.

Kerosene emulsion.
Kerosene and water mixture.
Whale oil soap.
Pyrethrum or buhach.
Tobacco.
Lime and sulphur wash.

Poisonous Gases.

Carbon bisulphide.
Hydrocyanic acid gas.

PARIS GREEN.

Paris green may be applied either as a dry dust or in the spray form. It is practically insoluble in water, but may be gotten into solution by treating with ammonia. When used as a spray either in pure water or in combination with bordeaux mixture, the liquid must be kept in a constant state of agitation, else the poison will settle and the liquid in the bottom of the barrel will be so strong that it will injure the foliage. For most pomaceous fruits one pound of Paris Green to 150 or 200 gallons of water is a good mixture. For the stone fruits, one pound to 300 or 350 gallons gives the best results. Many fruit growers are using stronger solutions, but the more concentrated they are the greater the danger of injuring the foliage. In all cases the liquid should be applied with force in the form of a fine mist. If applied in clear water it is well to add twice as much lime by weight as paris green. This will prevent any caustic injury to the foliage.

Where the use of an adulterant is suspected the ammonia test may be applied. Pure paris green will readily dissolve in ammonia, giving a deep blue color. If any residue remains or if the deep blue color does not appear at once, adulteration may be suspected. In lieu of ammonia, some grains of the powder may be

pressed between two pieces of window glass or between thumb and fingers; if a white powder appears it is an indication that some impurities are present.

WHITE ARSENIC.

White arsenic is becoming popular as a substitute for paris green. It is cheaper and its efficiency is greater. It may be safely used with bordeaux mixture or in combination with lime, but it should not be used alone in a soluble form, as it is very injurious to foliage. The following methods of preparation will be found satisfactory:

1.—*Arsenite of Soda.*—Dissolve four pounds of salsoda cystals in one gallon of water, add one pound white arsenic and boil until the crystals are all dissolved, which will require fifteen or twenty minutes. Add water to replace any lost in boiling, and place in an earthen vessel, where it may be kept as a stock solution. One pint of this solution is equivalent to four ounces of paris green. It may be used either with bordeaux, or water, one pint to fifty gallons. If used with water two pounds of freshly slaked lime should be added.

2.—*Arsenite of Lime.*—Dissolve one pound of salsoda in a gallon of water and add one pound of white arsenic. Boil until dissolved. Replace water lost by boiling, add two pounds of freshly slaked lime and boil for twenty minutes. Add water to bring the mixture up to two gallons. To fifty gallons of water add one quart of this solution and two pounds of lime paste.

LEAD ARSENATE.

Dissolve twelve ounces of acetate of lead in two quarts of water, and five ounces of arsenate of soda in the same quantity. As soon as dissolved pour the two solutions together into a spray tank containing fifty gallons of water.

Arsenate of lead remains in suspension better than paris green. It can be applied in larger quantities without injury to foliage, and its color renders it easily seen. It is valuable in combatting beetles and other insects which are hard to poison.

Arsenate of lead is sold on the trade under the name of "Disparene." If large quantities are to be used, it is often more eco-

nomical to make it at home, but if only a small amount is wanted, the commercial article would doubtless be cheaper.

HELLEBORE.

This is a powder obtained by pulverizing the roots of the white hellebore plant. It is a less violent poison than the arsenical compounds, and deteriorates rapidly when exposed to the action of the atmosphere. For this reason it is preferred for use on fruits which are soon to be placed on the market. It is especially recommended for treatment for the cherry, currant and gooseberry worms. When used in the powder form it should be diluted with three or four times its bulk of lime, plaster or flour. If the insect does not readily yield to this treatment an application of the pure powder may be advisable. If preferred it may be used with water at the rate of one ounce to three gallons. Apply with a sprinkling pot or spray pump.

KEROSENE EMULSION.

Kerosene	2 gallons.
Hard, Soft or Whale Oil Soap	½ pound.
Water	1 gallon.

Dissolve the soap in the water by boiling, remove from the fire and add the kerosene. Stir until a cream-like emulsion is formed from which the kerosene does not separate upon standing. This can best be accomplished by means of a spray pump, pumping the liquid back into the vessel. Before using, dilute to the desired strength. For the hard scale insects use strong emulsion, but for the soft scale insects which infest greenhouse plants, one part of kerosene to eight of water will answer. For such insects as plant lice, mealy-bugs, red spider and thrips, one part of kerosene to twelve or fifteen parts of water will prove effective. Cabbage and currant worms and rose slugs may also be successfully treated with the emulsion, which should always be used fresh.

For summer treatment of San Jose scale, use one pound of whale oil soap, two gallons of kerosene and twelve gallons of water.

KEROSENE AND WATER MIXTURE.

Two or three of the leading spray pump manufacturers have

recently put on the market pumps with a mechanical device attached for mixing kerosene and water, as it is applied. The pumps can be regulated to supply the kerosene and water in any desired proportions. However, they require constant attention, as it not unfrequently happens that the mixer refuses to work properly and only one of the liquids passes through the nozzle. A mixture containing from 25% to 40% kerosene may be applied to apple and pear trees while dormant, but the kerosene should not exceed 10% or 12% if the trees are in leaf.

The care exercised in making the application and the condition of the weather are important factors in determining the success of the treatment. The work should be done very carefully and then only on clear, bright days, so that the excess of oil will evaporate rapidly and not accumulate in drops on the trunk and larger branches of the trees. At the best they are dangerous sprays and should be used with caution. A mixture of one part kerosene to fifteen parts of water is sometimes used as a remedy for Pear-tree Psylla.

Pure kerosene and crude petroleum are also used for soft scale insects, but as both are injurious to plants when carelessly used, caution must be exercised in their application.

WHALE OIL SOAP.

Dissolve one pound of whale oil soap in five gallons of moderately hot water. This is to be used for treatment of mealy-bugs and similar insects. A solution of this strength will injure a few of the more tender plants. For use on dormant plants for San Jose scale, two pounds of soap to one gallon of water will give good results.

PYRETHRUM OR BUHACH.

This is a fine light brown powder made from the flower-heads of pyrethrum, and may be used either in the dust form or in solution. If used dry mix one part of the powder with three parts of flour and dust on plants. A liquid solution may be prepared by dissolving four ounces of the dry powder in a gill of alcohol and diluting with twelve or fifteen gallons of water. Apply with a spray pump. This remedy is effective against both chewing and

sucking insects, especially those that prey upon maturing fruits, flowers and vegetables.

TOBACCO.

In combating soft bodied insects tobacco may be used either in the form of a dust or a water decoction. Grind the stems to a powder and dust on the foliage. The water decoction is best made by placing the stems in a water-tight vessel, and adding boiling water. Allow the liquid to stand and dilute before using. The efficiency of tobacco water may be increased by adding one pound of whale oil soap to each fifty gallons.

Woolly aphis on the roots of fruit trees may be readily combatted by placing a few of the dry tobacco stems on the surface of the ground around the trunks of the tree, covering slightly with earth and moistening with water. A tea is thus formed which precolates to the roots of the tree and kills the insects on coming in contact with them.

CARBON BISULPHIDE.

This is a thin volatile liquid, the vapor of which is very poisonous to all forms of animal life. It is used against rodents, insects infesting grain in bins and those infesting the roots of plants, such as ants, plant lice and woolly aphis. The latter class may be successfully treated by forming a hole in the earth near the infested roots, pouring a small quantity of the liquid in and filling the hole with soft earth. The fumes readily penetrate the earth around the roots, killing the insects. In treating grain in bins, one pint of the liquid to one thousand cubic feet of bin space will be sufficient. The bin should be closed to prevent the escape of the gas. Do not use carbon bisulphide near an artificial light, as the fumes are very inflammable.

HYDROCYANIC ACID GAS.

This gas is used extensively for fumigating nursery stock, dormant fruit and shade trees, greenhouses, granaries, etc. It should be used in a gas-tight inclosure not only to render it more efficient against the insects, but to prevent injury to other forms of animal life. It is exceedingly poisonous. Experiments on greenhouse

plants show that a strong application of this gas may be very detrimental if great care is not exercised in the application. The best results are obtained with plants in foliage by using the materials in the following proportion:

Cyanide of Potassium	1 ounce.
Sulphuric Acid	2 ounces.
Water	4 ounces.

This amount is sufficient for 600 cubic feet of space. Pour the water into a glass or earthenware dish and add the sulphuric acid slowly. Place the receptacle in the proper position and add the cyanide. Do not inhale the fumes. It is a good practice to put the cyanide into a paper bag and drop it into the acid. This allows time to close the fumigating box before the acid dissolves the paper and comes into contact with the cyanide. The plants should be dry when treated and should not remain in the gas longer than fifteen minutes.

Hydrocanic acid gas for fumigating dormant nursery stock is made according to the formula given, but it should be used in a more concentrated form, and the exposure be longer. One ounce of cyanide of potassium, two ounces of sulphuric acid and four ounces of water, will generate sufficient gas for a fumigating box of one hundred cubic feet capacity. The stock should remain in the gas thirty to forty-five minutes.

LIME AND SULPHUR WASH.

Lime (unslaked)	15 pounds.
Sulphur	15 pounds.
Water	50 gallons.

Slake fifteen pounds of lime in a large iron kettle by adding slowly fifteen or twenty gallons of water, add fifteen pounds of sulphur and stir until the ingredients are thoroughly mixed. Boil for one hour and dilute to fifty gallons by the addition of water. The mixture should be stirred occasionally during the boiling to prevent the material settling to the bottom of the kettle. Apply to the dormant trees with a good spray pump. This wash should not be applied after the buds begin to swell.

It is a waste of time to use the wash if it has not been sufficient-

ly boiled. Prolosged cooking causes the formation of a number of the higher compounds of sulphur which are essential to the effectiveness of the wash.

If a large amount of spraying is to be done, the wash is best prepared in tanks made especially for the purpose. A number of such outfits have been described in the recent horticultural papers.

EXPLANATION OF PLATES I TO XII.

Plate I. A Sprayed Orchard.

Plate II. Bordeaux Mixture.

Figure 1. Forty-five minutes after mixing.

Figure 2. Four hours and thirty minutes after mixing. Tube A diluted before mixing; tube B mixed in concentrated form and diluted afterwards.

Plate III. Soda Bordeaux.

Figure 3. Photographed as soon as mixed.

Figure 4. Photographed after standing four hours. Tube A was diluted before mixing and B mixed concentrated and diluted afterwards.

Plate IV. Spraying Devices.

Figure 5. A spray pump mounted in a farm wagon.

Figure 6. Shows home-made wagon and horizontal tank.

Figure 7. Shows a good style of vertical tank.

Plate V. Nozzles.

Figure 8. Field Force Pump Co.'s Single Vermorel.

Figure 9. The Goulds Mfg. Co.'s Senica.

Figure 10. Field Force Pump Co.'s Niagara.

Figure 11. Morrill & Morley's Double Vermorel.

Figure 12. The Gould Mfg. Co.'s Mistry.

Figure 13. The Gould Mfg. Co.'s Calla.

Figure 14. The Deming Co.'s Deming Vermorel.

Figure 15. The Deming Co.'s Bordeaux.

Figure 16. The Field Force Co.'s Double Vermorel.

Plate VI. Pumps.

Figure 17. The Deming Co.'s "Peerless," showing mechanical agitator.

Fig. 5.

Fig. 6.

Fig. 7.

Figure 18. The Deming Co.'s Success Knapsack Sprayer.

Figure 19. The Deming Co.'s "Bonanza" Double-acting Spray Pump.

Figure 20. The Goulds mfg. Co.'s "Sentinel Jr." Double Acting Spray Pump.

Plate VII. Pumps.

Figure 21 The Deming Co.'s "Perfect Success" Bucket Spray Pump.

Figure 22. The Deming Co.'s "Century" Sprayer, showing submerged brass cylinder.

Figure 23. Morrill & Morley's large barrel of tank pump, with large cylinder and adjustable stroke.

Plate VIII. Pump.

Figure 24. The Field Force Pump Co.'s Empire King Spraying Pump with revolving agitator and brush for cleaning strainer.

Plate IX. Pumps.

Figure 25. J. F. Gaylord Defender Pump.

Figure 26. The Field Force Co.'s Niagara Hydraulic Spray Pump showing large air chamber.

Plate X. Tank Agitators, Pump and Stainer.

Figure 27. The Goulds Mfg. Co.'s Wooden Tank with agitator for use in large orchard.

Figure 28. Morrill & Morley's Upright Stave Tank for use in moderate sized orchards.

Figure 29. Morrell & Morley's large tank for use in extensive orchards.

Figure 30. Morrell & Morley's Material Strainer for use in preparing spray mixtures.

Figure 31. The Goulds Mfg. Co.'s "Standard" Spray Pump showing air chamber.

Plate XI. Vineyard and Nursery Rigs.

Figure 32. The Field Force Pump Co.'s "New Victor." Well adapted for use in vineyards or berry fields.

Figure 33. E. C. Brown's Nursery Rig for nursery stock or potato fields.

Plate XII. Power Pumps and Pressure Gauge.
Figure 34. Goulds Mfg. Co.'s Pressure Gauge.
Figure 35. The Deming Co.'s Gasoline Spraying Machine.
Figure 36. The Goulds Mfg. Co.'s Triplex Power Sprayer.

SPRAYING DEVICES.

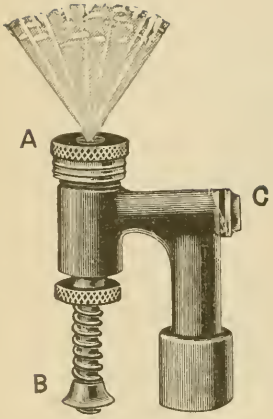
So many styles of spray machinery are now on the market that it is quite difficult to select the best, but there is, in fact, no *best,* outfit. The conditions under which spraying is done are so varied that only general recommendations can be made with safety, and each individual will have to select that which his judgment dictates. The pump and nozzle, best suited for use in an orchard of large trees, is manifestly out of place in the vineyard or berry field. Whatever the style selected the pump should be strong and capable of delivering a large amount of liquid with force. All parts that come into contact with the spray liquid should be of some material which the copper will not corrode, preferably hard brass. The body of the pump may be of either brass or iron.

It is also very important to have good valves and packing. Metal valves are to be preferred to those of other materials, but even they will not give satisfaction if they are not carefully ground to fit the valve-seats. The seat should be so placed that the minimum amount of sediment will collect on it. The packing may be of either leather, rubber or candle wicking. Leather withstands the action of kerosene better than rubber. Kerosene causes soft rubber to swell to such an extent that the pump is rendered worthless until repacked.

Knapsack pumps may be conveniently used about the garden, flower beds, vineyards and bush fruit plantations, but large trees cannot be successfully treated with these as they do not develop power sufficient to carry the liquid to the tops. The greatest objection that may be urged against them is that the operator must of necessity carry the weight of both the liquid and pump on his back.

Bucket pumps, Fig. 21, are excellent for use in gardens, vineyards and green houses. Moderate sized trees may be thoroughly sprayed with them and where little work is to be done they may

PLATE V.—NOZZLES.



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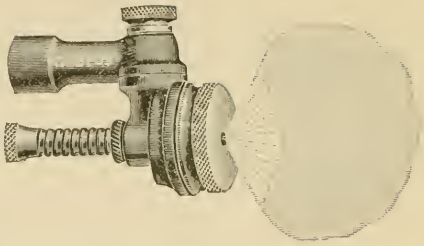

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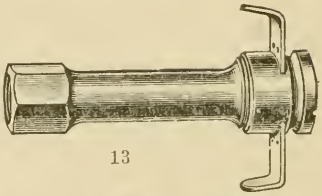

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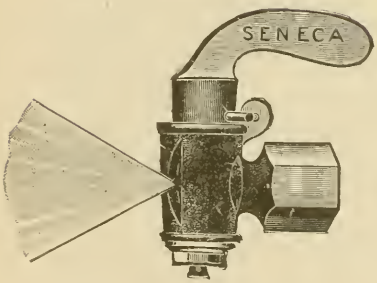

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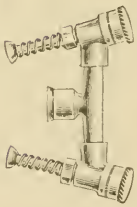

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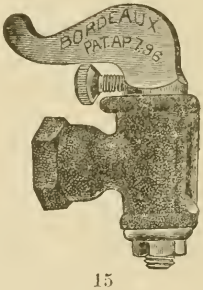

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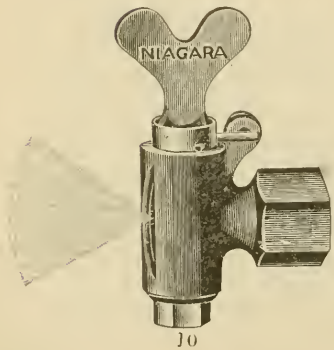

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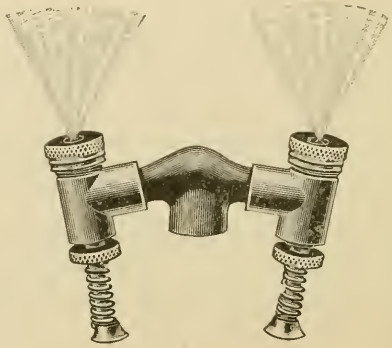

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PLATE VI.—PUMPS.

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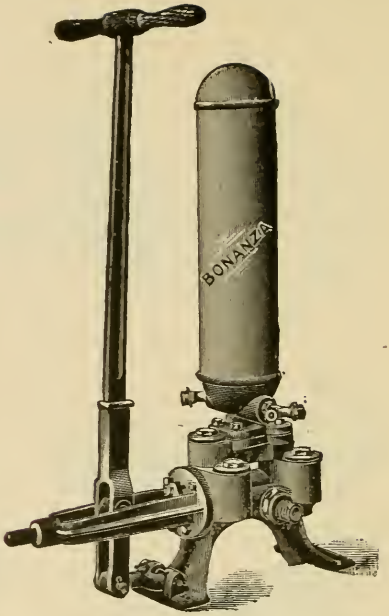

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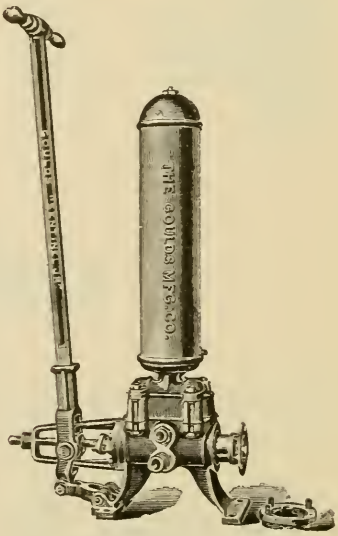

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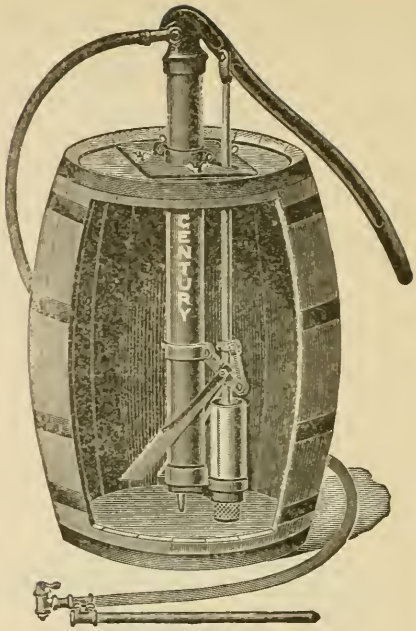

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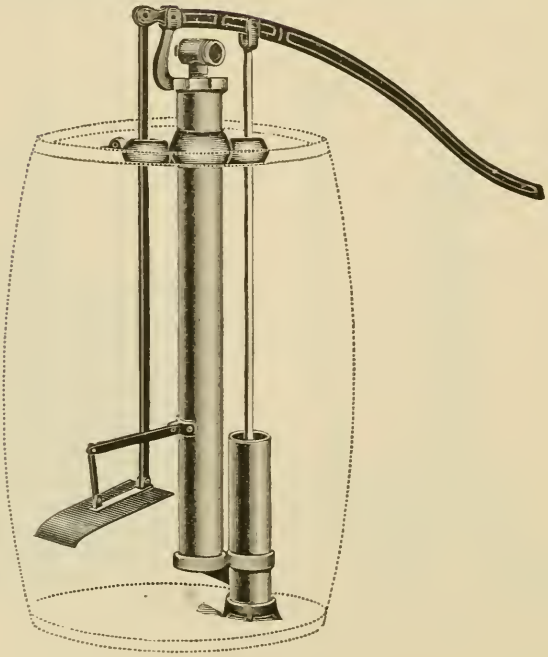

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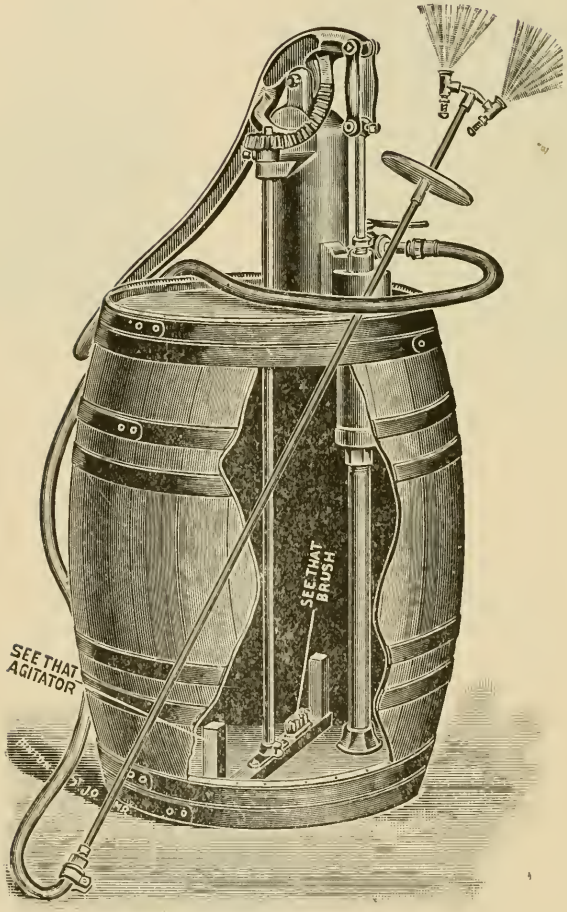
PLATE VIII.—BARREL AND PUMP.



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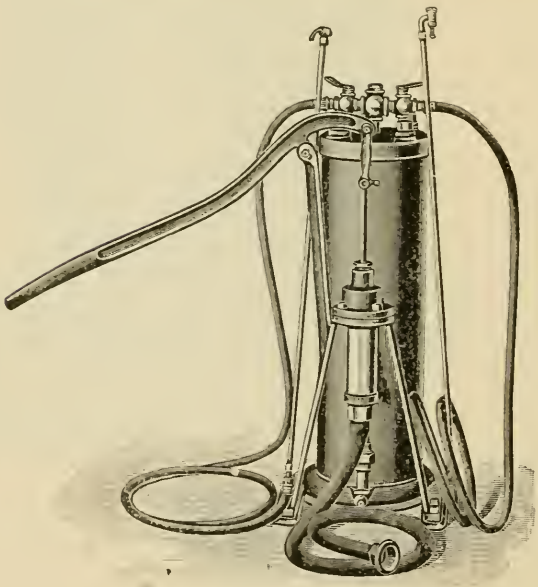

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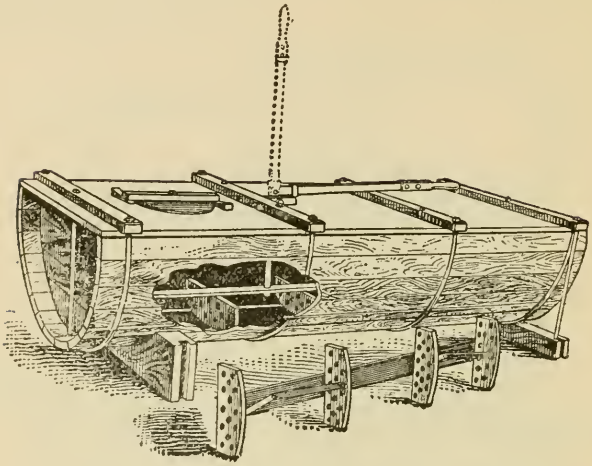
PLATE X.—TANKS, AGITATOR, PUMP AND STRAINER.



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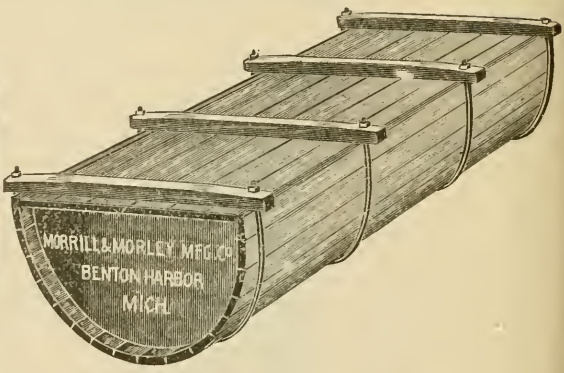

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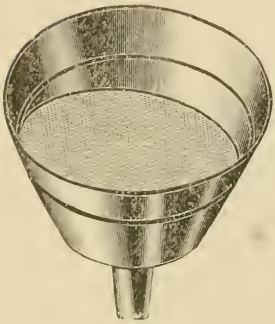

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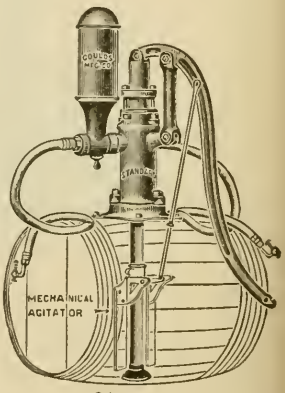

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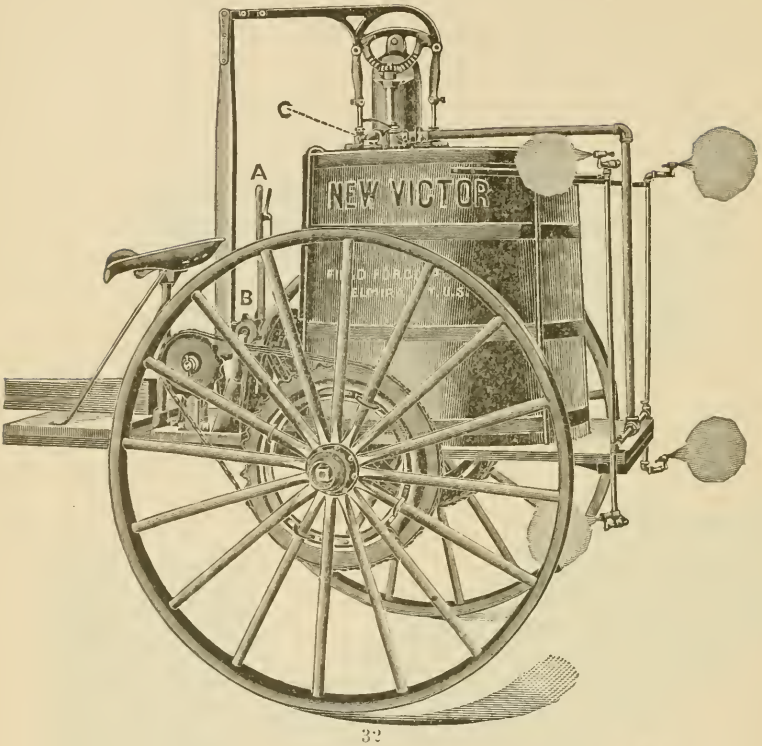
PLATE XI.—VINEYARD AND NURSERY RIGS.



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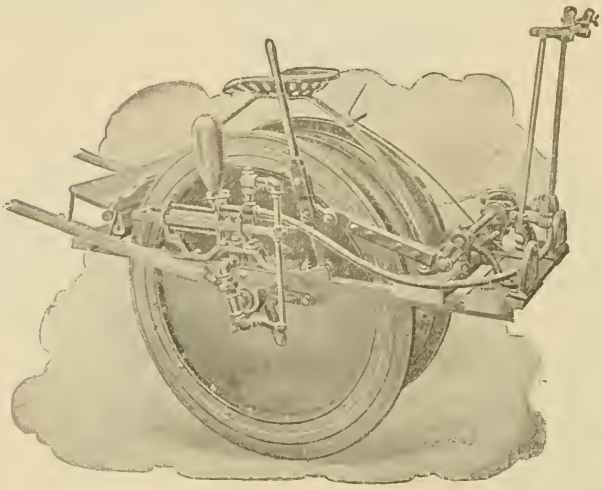

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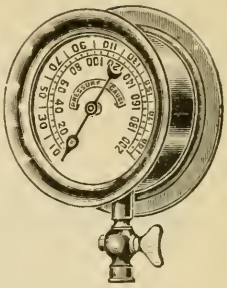
PLATE XII.—POWER PUMPS AND PRESSURE GAUGE.



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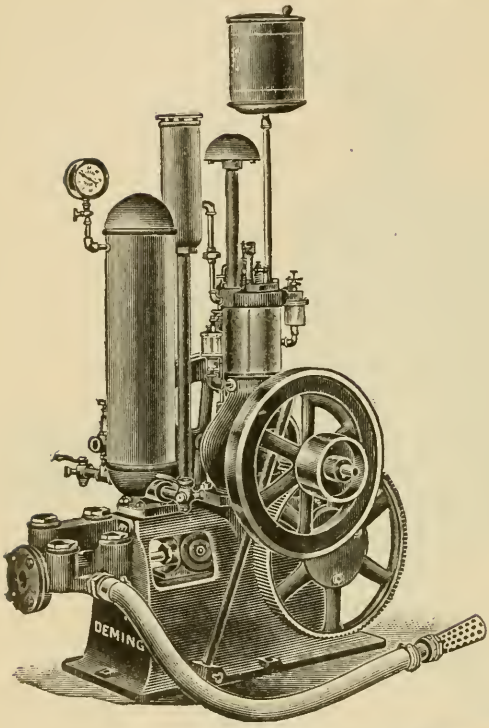

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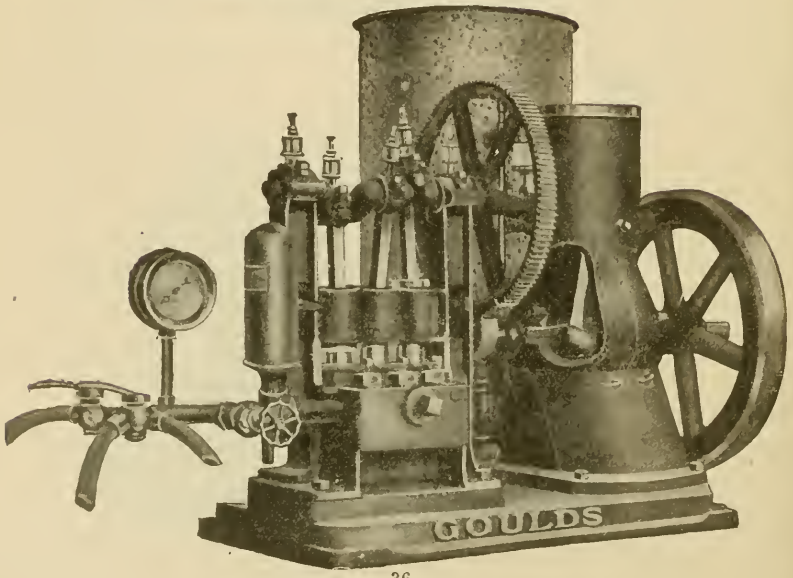

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be substituted for the larger styles. Manufacturers' catalogues frequently state that the pump may be successfully used for general orchard work, and in a few instances they may, but the work is so tedious and so much time is consumed that their use for this class of spraying is seldom economical. A larger pump will throw more liquid and do it easier, so it is a mistake to purchase a small outfit if many large trees are to treated. However, the bucket pump is a very important adjunct to any well equipped farm.

Barrel pumps, Figs. 17, 22, 24, and 25, are undoubtedly the favorite for general orchard work, and the great variety of these on the market renders it difficult to select the one best suited for the particular work. The relative merits of those placed on the market by the different manufacturers will not be discussed but a few suggestions in regard to selection in general will be given.

All barrel spray pumps should be provided with a cylinder capable of delivering liquid for two leads of hose, each fitted with double nozzles. This requires a diameter of two and one half to three inches. The cylinders should be lined with a non-corrosive material such as porcelain or brass. Porcelain has proven unsatisfactory in many instances because of its tendency to crack and the great difficulty of maintaining an even surface. The stroke should be at least four or five inches in length. The packing around the piston should be of leather, candle-wicking or some of the compositions which will not cause useless wear on the cylinder and at the same time resist the action of the spray mixture.

Some pumps have the cylinder submerged in the liquid while others have it placed on the outside of the barrel. Pumps with the cylinder submerged near the bottom of the barrel have certain advantages. They need no priming, simpler valves may be used, and there are no projecting parts to catch the branches of the trees. One of the merits of the pump with the cylinder above the barrel is the ease with which the working parts may be reached, thus admitting of any slight repairing without removing the pump from the tanks.

The handle of the pump is also an important item. No small amount of power is required to work a large sized piston against a column of liquid and at the same time throw a stream to the top

of a tree with sufficient force to break into a fine spray. This can be done with comparatve ease if the length of the handle is properly proportioned. The distance from the pivot to the end should be at lesat six times as great as from the pivot to the piston rod. From two to two and one half feet is a popular length.

Most of the pumps illustrated in this bulletin are provided with a mechanical agitator which keeps the liquid in the tank in motion. These are either of the dasher style, Fig. 25, or the whirling paddle type, Fig. 24. Barrel pumps are usually provided with the former, while most tanks are fitted with the latter. Some pumps are provided with a return hose which forces a portion of the liquid back into the tanks, thus setting up a current. This has not proved altogether satisfactory. Some orchardists prefer to stir the mixture by hand with a paddle. It is important to keep the liquid well stirred and the device that will accomplish this with the least expenditure of time and energy is the most desirable. Orchardists in this State seem to prefer the dasher type.

Good spraying cannot be done with a poor nozzle, and there is no one nozzel that is best for all purposes. The ideal device should deliver the spray at the desired point in the form of a fine mist. A nozzle that breaks the liquid into a mist at the orifice is of little use in spraying the tops of very tall trees but is admirable suited for work on trees which can be reached with the extension rod. For work in the top of tall trees the nozzle should deliver a solid stream with good carrying power, which, contact with the atmosphere finally breaks into a fine mist. The bordeaux style of nozzle is probably best suited for this class of work. This, however, does not give entirely satisfactory results because it is impossible to break the whole stream into a mist at the desired point. Where it can be done it is much better to use a long extension rod and a nozzel of the Vermorel type. The outfit is incomplete if it does not contain nozzles of both types.

SPRAYING APPLES FOR CODLING MOTH.

During the season of 1903 a series of experiments to determine the relative efficiency of Paris green and white arsenic in combatting the codling moth was conductaed in the orchard of R. C. Burkhart, near Martinsburg.

At the time the spray was applied, May 15th, about 75% of the individual fruits were in such condition that the spray could enter readily. Since it is the first fruits set which perish the results would probably have been more satisfactory if the application had been made two or three days earlier, but local conditions interfered.

The trees were sprayed with bordeaux mixture, containing 4 pounds copper sulphate, 4 pounds lime and 50 gallon of water to which the various strengths of poison were added. The weather conditions were very favorable.

The treatment and results are given beyow in tabulated form. The first column gives the number of trees treated, the second the variety, the third the amount of poison used per 50 gallon of bordeaux mixture, the forth the number of barrels of No. 1 fruit produced, the fifth the number of barrels of culls, the sixth the number of wormy apples found in the culls, the seventh the windfalls, the eighth the number of worm apples in the windfall and the ninth the percentage of foliage free from injury by either insect or fungus pests.

Table Showing Results of Spraying.

No. of trees.	Variety.	Poison.	Barrels of Fruit.		No. of worm eaten fruits.	Barrels wind falls.	No. of worm eaten fruits.	Compition of foliage.
			1st Class.	Culls.				
2	Ben Davis.	8 oz. Paris green....	9.	1.	63.	1.	50	80p.c.
2	Ben Davis.....	8 oz. Paris green ...	10.	1.25	65.	1.	67	80 "
2	Ben Davis.....	8 oz. Paris green ...	5.	.5	28.	.5	31	78 "
2	Ben Davis.....	3 oz. white arsenic.	12.	2.	170	1.5	186	70 "
2	Ben Davis.....	4 oz. white arsenic.	6.	.87	57	.75	61	70 "
6	Ben Davis.....	Untreated	11.	4.	519.	3.	364	50 "
2	York Imperial ..	3 oz. white arsenic.	8.	.5	20.	3.	20	80 "
2	York Imperial ..	2 pounds Disparine.	12	1.	84	.87	64	82 "

It will be seen from the table that the six Ben Davis trees treated with Paris green produced 29.25 barrels of fruit, 82% of which was graded as No. 1, while the six untreated trees produced only 17 barrels, 64.7% being graded No. 1. A comparison of the amount of No. 1 fruit from the two lots shows that the untreated yielded only 46.6% as much as the treated, while the number of wormy apples in the former was 2.57 times as great as in the latter. The foliage on the sprayed trees as 30% beter than on the unsprayed.

White arsenic, on the Ben Davis trees, did not prove so efficacious as paris green in controlling the codling moth or preventing insect injury to foliage, 77.8% per cent. of the fruit being marketable and the condition of the foliage being 20% above the unsprayed.

The number of larvaeni-fested apples was also larger, averaging 10.4 for paris green and 20.5 for white arsenic treatment per barrel. But the results with the York Imperials was more satisfactory, 88.9% grading No. 1, the foliage 30% above the untreated and the number of infested apples averaging 4.4 per barrel.

Four ounces of white arsenic gave much better results than three, especially in checking the moth, the average number of infested fruits per barrel being 15.6 as against 22.8 for the three ounces application.

The application of disparene at the rate of 2 pounds per barrel of bordeaux gave satisfactory results also, 86.5% of the fruit being marketable. The number of insect injured apples averaged 10.6 per barrel.

A comparison of results on all the sprayed to the unsprayed trees shows that the former yielded an average of 4.43 barrels of No. 1 and .91 barrels of culls, while the latter produced only 1.83 barels of No. 1 and 1.16 barrels of culls per tree, thus giving 2.6 barrels of marketable fruit more from a sprayed tree than from an unsprayed tree.